

tube of the funnel was bent upwards and had an orifice about 1-20th of an inch in diameter. Close above this orifice was placed a glass slide, held by springs and bearing a drop of glycerine on its lower surface. The tube and glass slide were protected by a roof and two cheek-boards, which formed the vane of the weather-cock. The glass slide was so placed that the current of air issuing from the narrow orifice of the bent tube, under pressure of the wind on the wide mouth of the funnel, impinged on the centre of the drop of glycerine, and a large proportion of any solid matters carried by the air was caught on the glycerine. After a day or two, according to the weather, the slide was removed, a thin disk of glass was placed on the glycerine-drop, and the contents were then examined under the microscope, a duplicate slide being left in the aeroscope for the next observation.

This instrument depended for its function on the wind. If there was no wind, there was no current through the tube, and nothing was caught on the glycerine; but in general there was wind enough, and the captures were ample, often embarrassing by their multitude. The observations were mostly made in the neighbourhood of London, at the Greenwich Observatory. The nature of the captures varied according to the direction and velocity of the wind, the state of the weather, and the season of the year. A north-west wind, blowing over London, brought soot and globules of coal-tar, textile fibres, nondescript *débris*, a few vegetable spores, now and then an epithelial scale or two, always a number of half-cooked starch-grains (identified by their reaction with iodine and by traces of concentric lamination giving a black cross with the polariscope), and sometimes microscopic bread-crumbs (half-cooked starch-grains in meshes of gluten). The starch-grains were the most constant capture of all, in all seasons and for all directions of wind. They seem to be very durable. (If I remember rightly, M. Pouchet found starch-grains in all specimens of dust, even the most ancient, obtained from the neighbourhood of human dwellings.) A southerly wind, blowing from the country, brought a great variety of vegetable spores and pollen-grains and *débris*, with a smaller proportion of matters characteristic of town air. The size and quantity of the captures depended mainly on the velocity of the wind. Once or twice a strong wind swept a living acarus, or an entomostrocan, or the shell of a diatom into the glycerine. In dry windy weather a quantity of siliceous sand was caught, which gave trouble by tilting the disk when in preparation for the microscope, and the larger grains had to be removed with the point of a needle.

The most interesting variation in the character of the organic captures was that which depended on the season of the year. In January and February scarcely anything was found (besides *débris* and inorganic matter) but a few fragments of mycelium of some fungus; but with the first fine weather in March the glycerine began to yield good returns. Spherical grains of poplar pollen were caught in large numbers, thirty or forty in a single drop, though the nearest poplar tree was a quarter of a mile distant. These were soon followed by the triangular pollen of birch and hazel—trees depending, like poplar, on the agency of the wind for fertilisation. From this time onward, through spring and summer, a great number and variety of pollen grains were caught. Cryptogamic cells increased in number through the summer, and reached their maximum in the autumn, when brown septate spores and others of various kinds, which my imperfect knowledge did not enable me to identify, appeared in abundance. If left for some days, they began to germinate. Towards winter their number diminished, the latest being minute dark brown oval spores of some species of agaricus (?). The winter months were comparatively barren.

I did not find any Bacteria, but there were numbers of excessively minute particles, of which I could not tell the nature. Once, after leaving the aeroscope for several days, I found the glycerine swarming with a minute *torula* which had evidently multiplied in that pabulum. In fact the glycerine was fermenting.

Among these facts, the only one which seems to have any bearing on the question of the propagation of infectious diseases is the great prevalence of cryptogamic spores in the air in autumn, when those diseases are especially rife.

To avoid fallacy in the results obtained, I used to place two drops of glycerine on the same slide, but only directed the air-current against one of them; both were examined under the microscope, and the difference credited to the air. By using glycerine that had been boiled with carmine, many of the

organic captures were made more distinct: the nuclei of epithelial scales and of many other cells were brightly stained by the carmine. Glycerine had the disadvantage of absorbing moisture in damp weather and swelling to an inconvenient bulk. At such times I used oil instead, with good effect. My plan of examination was to sweep the whole disk in successive parallel zones, by the aid of mechanical stage-movement, and make record of every organic body that could be recognised. Such as I had not seen before were sketched with pen and ink and coloured chalk in a book devoted to that purpose.

It will be seen that my observations entirely support Mr. Cunningham's, as to the abundant presence of living spores in the air. I was satisfied that this branch of research, in the hands of one thoroughly familiar with these microscopic forms, would lead to results of great interest, and I heartily congratulate Mr. Cunningham on the valuable work which he has produced.

HUBERT AIRY

### Animal Locomotion

MR. WALLACE's last letter seems to call for a word of explanation from me. I did not refer to the up stroke of the bird's wing because this was not the point in dispute. But in reply to Mr. Wallace's latest stricture—that I appear “to ignore the great downward reaction, added to gravitation, during every up stroke”—I would say (1) that the downward reaction is not great, (a) because, as Mr. Wallace has himself observed, of the valvular action of the feathers; (b) because of the convex form of the upper surface of the wing; and (c) in some cases, because the wing is less expanded in the up stroke. (2) As to the effect of gravitation, this was already allowed for in determining the resultant motion consequent on the down stroke, and must not be reckoned twice. Just as with an arrow shot from a bow, so with the bird; the motion consequent on the down stroke lasts long enough for the wings to be raised before it is spent. Mr. Wallace is certainly right in saying that the down stroke should counteract the downward reaction of the up stroke, but this downward reaction being slight cannot require “a highly-inclined upward motion,” and what is more, it cannot require that the under surface of the wing should be directed forwards as Dr. Pettigrew asserts.

Again, I do not say the movement of the wing as a whole is downward and backward, but that the action of its surface is in that direction. The Duke of Argyll is no doubt correct in maintaining that the wing as a whole moves in a perpendicular line, or perhaps with a slight forward overlap.

I cordially agree with Mr. Wallace that the matter is not to be settled by “discussing theoretically, but by observation and experiment;” still the elementary principles of mechanics may surely be heard in evidence without disadvantage even at the outset of the inquiry.

JAMES WARD

Trinity College, Cambridge, March 30

### Rudimentary Organs

IN a former communication (NATURE, vol. ix. p. 361) I promised to advance what seems to me a probable cause—additional to those already known—of the reduction of useless structures. As before stated, it was suggested to me by the penetrating theory proposed by Mr. Darwin (NATURE, vol. viii. pp. 432 and 505), to which, indeed, it is but a supplement. Epitomising Mr. Darwin's conception as to the dwarfing influence of impoverished conditions, progressively reducing the average size of a useless structure, by means of free intercrossing; the present cause may be defined as the mere cessation of the selective influence from changed condition of life.

Suppose a structure to have been raised by natural selection from 0 to average size 100, and then to have become wholly useless. The selective influence would now not only be withdrawn, but reversed; for, through Economy of Growth—understanding by this term both the direct and the indirect influence of natural selection\*—it would rigidly eliminate the variations 101, 102, 103, &c., and favour the variations 99, 98, 97, &c. For the sake of definition we shall neglect the influence of Economy acting below 100, and so isolate the effects due to the mere withdrawal of Selection. By the condition of our assumption, all variations above 100 are eliminated, while below 100 indiscrimi-

\* See former communication, NATURE, vol. ix. p. 361.

nate variation is permitted. Thus, the selective premium upon variation 99 being no greater than that upon 98, 98 would have as good a chance of leaving offspring (which would inherit and transmit this variation) as would 99: similarly, 97 would have as good a chance as 98, and so on. Now there is thus a much greater chance of variations being perpetuated at or below 99, than at or above 100; for at 100 the hard line of Selection (or Economy) is fixed, while there is no corresponding line below 100. The consequence of free intercrossing would therefore be to reduce the average from 100 to 99. Simultaneously, however, with this reducing process, other variations would be surviving below 99, in greater numbers than above 99; consequently the average would next become reduced to 98. There would thus be "two operations going on side by side—the one ever destroying the symmetry of distribution" round the average, "and the other ever tending to restore it." It is evident, however, that the more the average is reduced by this process of indiscriminate variation, the less chance there remains for its further reduction. When, for instance, it falls to 90, there are (numerically, though not actually, because of Inheritance) 89 to 9 in favour of diminution; but, when it falls to 80, there are only 79 to 19 in such favour. Thus (theoretically) the average would continue to diminish at a slower and slower rate, until it comes to 50, where, the chances in favour of increase and of diminution being equal, it would remain stationary.

Having thus, for the sake of clearness, considered this principle apart, let us now observe the effect of superadding to it the influence of the Economy of Growth—a principle with which its action must always be associated. Briefly, as this influence would be that of continually favouring the variations on the side of diminution, the effect of its presence would be that of continuously preventing the average from becoming fixed at 50, 40, 30, &c. In other words, the "hard line of Selection," which was originally placed at 100, would now become progressively lowered through 90, 80, 70, &c.; always allowing indiscriminate variation below the barrier, but never above it.

It will be understood that by "cessation of selection from changed conditions of life" I mean a change of *any kind* which renders the affected organ superfluous. Take, for example, the exact converse of Mr. George Darwin's illustration, by supposing a herd of cattle to migrate from a small tract of poor pasture to a large tract of rich. Segregation would ensue, the law of battle would become less severe, while variation would be promoted in a cumulative manner by the increase of food. The young males with shorter horns would thus have as good a chance of leaving progeny as "their longer-horned brothers," and the average length would gradually diminish as in the other case. Of course, as the predisposing cause of impoverished nutrition would now be absent, the reducing process would take place at a slower rate. Moreover, it is to be remarked that this principle differs in an important particular from that enunciated by Mr. Darwin, in that it could never reduce an organ much below the point at which the Economy of Growth (together with Disuse) ceases to act. For, returning to our numerical illustration, suppose this point to be 6, the average would eventually become fixed at 3.

That the principle thus explained has a real existence we may safely conclude, theoretical considerations apart, from the analogy afforded by our domestic races; for nothing is more certain to breeders than the fact that neglect causes degeneration, even though the strain be kept isolated. It will be observed that, if this principle has a real existence, it is of considerable importance, theoretically, since it must act, to a greater or less extent, in all cases where Disuse and the Economy of Growth are in operation; and although in the initial stages of reduction, when the purchase, so to speak, of the last-named principle is great, its influence would be comparatively trivial, this influence would be more and more felt the smaller the organ became—*i.e.*, the nearer the point at which the Economy of Growth ceases to act. The Cessation of Selection should therefore be regarded as a reducing cause, which co-operates with other reducing causes in all cases, and which is of special importance as an accelerating agent when the influence of the latter becomes feeble.

GEORGE J. ROMANES

#### Lakes with two Outfalls

ON June 22, 1863, the late Captain Speke published his map, giving (on native authority) *four* outlets from Lake Victoria Nyanza, converging to *one* valley or water-flow—the Nile.

On June 27 and on July 20 I wrote to the *Athenaeum*:—"I think that this native information will prove to be erroneous;" that I thought "that no lake can have more than one outlet;" and I added, "May I lay the question as to the matter of fact before the readers of the *Athenaeum*?" In reply, the Black Loch in Dumfriesshire was stated to have *two* outlets to *two* distinct valleys or water-flows—one to the Nith, the other to the Ayr. The Loch, however, has but one outlet, and that *artificial*. The water-parting has been cut through by man—a mill-lead made to Lord Bute's Borland mill, and the one outlet is an iron sluice in a stone dam. All this is beautifully shown in Sir Henry James's admirable 25-inch Ordnance Maps.

Dr. Bryce ("Geology of Arran," 3rd edition, p. 3) says that Loch-an-Davie has two outlets to two different valleys. It has, however, but one outlet, to the south—to Glen Torsa, as I stated in the *Athenaeum*, July 22, 1865. The new inch Ordnance Map of Arran gives one outlet, but unfortunately to the north, instead of to the south. I will not refer to my letter on the two outlets to two valleys from the Norwegian Lesjeskaugen Lake, which you did me the honour to publish last September, and with which Prof. Stanley Jevons agreed. But I quote the above cases to show that even the highest authorities make mistakes as regards lakes and their outlets. I cannot, however, suppose any mistake in Prof. Bell's account of the two outlets to two valleys from Shoal Lake, published in *NATURE*, vol. ix. p. 363, by Prof. Dawson. I would then, in deference to these authorities, modify my dictum by saying, that if by a rare possibility a lake may be found to exist on a water-parting having at opposite ends two outlets to two different valleys, I should still doubt the possibility of a lake at its one lower end having a multiplicity of outlets converging to one valley or water-flow, as in the case of the Victoria Nyanza. And this owing to the extreme improbability that the erosion at each outlet should continue at precisely the same rate.

The outlet of every lake in the wide, wide world is always being lowered from erosion, as are valleys themselves. Valleys exist only in the dissolution of hills. They are mere water-flows. They are the perpetually changing effects of atmospheric disintegration, and the erosion of rain and rivers, and consequently every water-parting is a valley-parting.

Alresford, March 14

GEORGE GREENWOOD

#### A Beech pierced by a Thorn Plant

ON the road from this to Belfast there is a thorn hedge with beech trees at intervals, and thorn plants have grown right through the middle of the trunks of two of the beeches. I do not know whether this is sufficiently uncommon to be worth mentioning in *NATURE*.

Old Forge, Dunmurry, co. Antrim

JOSEPH JOHN MURPHY

#### KINETIC THEORY OF THE DISSIPATION OF ENERGY

IN abstract dynamics an instantaneous reversal of the motion of every moving particle of a system causes the system to move backwards, each particle of it along its old path, and at the same speed as before when again in the same position—that is to say, in mathematical language, any solution remains a solution when  $t$  is changed into  $-t$ . In physical dynamics, this simple and perfect reversibility fails on account of forces depending on friction of solids; imperfect fluidity of fluids; imperfect elasticity of solids; inequalities of temperature and consequent conduction of heat produced by stresses in solids and fluids; imperfect magnetic retentiveness; residual electric polarisation of dielectrics; generation of heat by electric currents induced by motion; diffusion of fluids, solution of solids in fluids, and other chemical changes; and absorption of radiant heat and light. Consideration of these agencies in connection with the all-pervading law of the conservation of energy proved for them by Joule, led me twenty-three years ago to the theory of the dissipation of energy, which I communicated first to the Royal Society of Edinburgh in 1852, in a paper entitled